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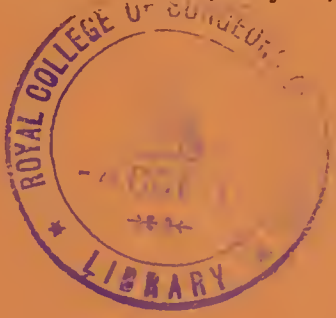
Reprinted from the Journal of Physiology.
Vol. XLII. Nos. 5 & 6, July 15, 1911.



[*Reprinted from the Journal of Physiology,*
Vol. XLII. Nos. 5 *&* 6, *July* 15, 1911.]

SUBJECTIVE AND OTHER PHENOMENA CONNECTED WITH THE RETINA.

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This paper is in continuation of that on visual phenomena connected with the yellow spot, in this *Journal*, XLI. p. 263. The figures referred to in this paper are those given in the previous one.

1. *The effect of the blood in the vessels of the retina.* It occurred to me that if we could suddenly be made conscious of the absorption of green rays by the blood, since the cones in the vascular area are influenced only by those rays that pass through the blood, the colour of the absorbed rays would appear as a contrast effect in the field of vision corresponding to the non-vascular portion of the retina. The effect can be shown in two ways.

1. If we look through a blue-green glass at a uniformly illuminated white surface as, for instance, a white cloud in the sky, for about 30 seconds, on removing the glass the whole of the field of vision appears rose, with the exception of the centre corresponding to the central non-vascular portion of the retina; this appears bright green. The colour of the green is pure green and not a blue-green similar to the colour of the glass. It will be noticed that there is a brighter portion forming the star figure already described (Fig. 7). The colour of the surrounding field of vision is rose and not red, the complementary of the blue-green glass. As the colour seen is very similar to that of the visual purple it might be thought that this was the cause of the phenomenon. The green area, however, corresponds to the non-vascular portion of the retina and not to the rod free portion, and I have never seen this green colour in conditions in which visual purple phenomena become evident.

2. On looking at a sky, which is obscured by a white fog, for 20 seconds with one eye, the other being closed and covered with the

hand: on removing the hand from the covered eye after opening it, the centre of the field of vision is seen as pure green, the star-shaped figure being seen as in the previous experiment. The surrounding part of the field of vision does not change colour but appears white as it did before opening the covered eye. The light transmitted through a white fog contains a preponderance of red rays as may be seen by viewing a light or the sun through it: both appear much redder than usual.

II. *Visual phenomena caused by pressure on the eye.* If gentle pressure be made on the front of one eye with the palm of the hand a star-shaped figure with four rays is seen, bright on a dark ground. It is similar in every respect to the central star part of Fig. 7.

When both eyes are covered with the hands and more prolonged pressure is made on the right with the palm a rhomboidal figure is seen. This is formed through the filling up of the spaces between the rays of the star and the points of the rhomboid correspond to the extremities of the rays of the star. In addition bright lines are seen moving in a whirling fashion from the periphery towards the centre. The appearance is exactly the same as that of the currents I have already described. It is evident that Helmholtz saw the phenomena as I do as his description[1] will apply admirably to the currents and star figure I see on prolonged pressure.

III. *Various effects of intermittent light.* If we note the effects of intermittent light upon the retina it will be found that the phenomena which are seen apparently change. All are phenomena which have been described, but they are seen at different times. For instance, if the open fingers be moved rapidly before one eye whilst the vision is directed towards a white cloud in the sky, we may see in succession some or all of the following but not necessarily in the order given.

1. Löwe's ring, Maxwell's spot and the fovea.
2. The appearance of the blood vessels of the retina.
3. The vascular network due to the capillaries of the retina. The non-vascular portion is seen as a uniform white circle surrounding a granular disk.
4. Appearances due to the yellow pigment of the yellow spot.
5. The star figure and currents.
6. Appearances due to the pigment cells of the retina.
7. The eight-rayed star due to the lens.

[1] *Physiol. Optik*, II. Aufl. S. 237.

IV. *Effect of moving material on centre of retina.* On opening one eye on awaking in the morning and looking at the ceiling the central portion is seen as an irregular, circular, rhomboidal or star-shaped black spot. On closing the eye again a bluish violet circle appears at the periphery or middle of the field of vision, contracts and then after breaking up into the star-shaped figure and becoming brighter disappears to be followed by another contracting circle. If the eye be opened when the star figure has formed in the centre it will appear as a bright rose-coloured star, much brighter than any other part of the field of vision. If however we wait till the star has broken up and disappeared before opening the eye, it will be found that only a black spot is seen in the centre.

V. *Time of interval between contracting circles.* I have timed the contracting circles with a stop-watch and find that the interval between two is very irregular. They may follow each other regularly at intervals of one or two seconds and then cease. They are not apparently synchronous with the pulse or respiration and they still go on moving when I hold my breath.

VI. *Effect of light on size and colour of currents.* When the light which is entering the eye is diminished a broad current narrows to a thin line. The circles in these circumstances contract to thin lines which are at an angle to the circumference of the circle and are not joined together. The colour of the circles and currents is with very dim light bluish white, with more light bluish violet, and as more light is added the colour becomes redder and redder until it is finally rose.

VII. *Effect of light on the star figure.* The central part of the star figure is seen with dim light. If more light is allowed to enter the eye the star figure changes into a rhomboid, exactly as it did when seen by pressure and the pressure was increased.

The currents and star can be seen very well in a dim light, as for instance that of a white blind illuminated by moonlight. On moving the open fingers before one eye, the labyrinth of whirling currents is well seen with the star figure in the centre. The movement continues for several seconds after the hand has been removed from the eye.

VIII. *Effect of blow on the eyeball.* I was suddenly thrown off my bicycle by riding over an object in the road and struck the outer side of my right eyeball on the ground. A bright rose-purple light was visible in the corresponding part of the field of vision for several hours after the accident.

IX. *Effect of moving material on appearance of small lights.* If a small light be looked at in a dark room, as for instance, that coming through the smallest diaphragm of my colour perception lantern which represents a $5\frac{1}{2}$ inch bull's eye railway light at 1000 yards, care being taken not to move the eye, the contracting bluish violet circles will be seen. The colour of the circle is the same for white light or any coloured light. When it reaches the centre the light brightens. If the circles stop the light disappears.

X. *Illusion of moving light.* In many cases in repeating the above experiment the light will appear to move. This is particularly noticeable with red light but may be seen with any other. The light appears to move until it apparently comes close enough to be grasped by the hand when it is really 20 feet off. I have the impression the whole time that I am looking straight at the light when it is really falling upon a peripheral part of the retina. The other closed eye is still directed straight at the light and on opening this eye two images of the light are seen which rapidly coalesce, the peripheral image joining the central one. The light appears to move as if some substance went downwards by gravity: when the head is upright the image appears to move upwards, when bent to one side the image appears to move in the opposite direction but appears to approach during its movement.

XI. *Phenomena seen on closing one eye.* If in the morning on awaking I look at the white ceiling with both eyes the black spot appears and disappears as usual. If I then close one eye, bright curved lines appear in the periphery of the field of vision and the centre becomes bright.

XII. *Yellow spot region seen on opening an eye.* I find that if one eye be directed to the sky whilst the other eye is closed and covered with the hand, when the second eye is opened the region corresponding to the yellow spot is seen as a much lighter spot. This phenomenon is seen very well at night when there is a clear sky.

XIII. *Influence of a light on surrounding regions of retina to that which is stimulated.* If a light be looked at steadily with one eye when it has dark surroundings incapable of reflecting any light, it will appear to be surrounded by a halo made up of numerous rays of the same colour as the light. If the light be white the rays look like thin rivers running towards the light. Each point of these rivers becomes alternately rose and green, that is to say a rose-coloured particle appears to be followed by a green one which is again followed by another rose particle. On covering the eyes with the hands after shutting them a

pure green patch is seen corresponding to the light. This is surrounded by rose corresponding to the rays. The rose gradually encroaches on the green which does not change colour. On opening the eyes a bright rose patch is seen which does not change colour but gradually fades away.

XIV. *Bright spots seen in the field of vision.* I have several times noticed on stooping on a sunny day, that bright spots have appeared in the field of vision. These have formed a circle which gradually contracted, each spot becoming smaller and brighter as the centre was reached. The appearance exactly corresponded to Fig. 4 seen from without inwards.

All these phenomena are explained in a similar manner to those in the first paper. They show that the foveal region is sensitized from the periphery and this corresponds to the diffusion of the visual purple into the liquid surrounding the cones and so into the fovea. Photo-chemical substances have the maximum of their sensitiveness shifted more towards the red end of the spectrum when a light is increased in brightness, and this would account for the redder appearance of the effect of the visual purple when more light is allowed to enter the eye.

Helmholtz describes the halo mentioned in Exp. XIII and attributes the phenomenon to diffraction from the edges of the iris and irregular refraction.